GLASSWOOL (Respirable Size)*

First Listed in the *Seventh Annual Report on Carcinogens*

CARCINOGENICITY

Glasswool (respirable size) is *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity in experimental animals (IARC, V. 43, 1988). Rats and hamsters receiving glasswool (length - <3.2 to <7 µm; diameter - <0.18 to <1 µm) by intratracheal instillation developed adenocarcinomas, squamous-cell carcinomas, bronchoalveolar tumors, lung carcinomas, mesotheliomas, and sarcomas. When administered by intraperitoneal injection (length - <2.4 to <30 µm; diameter - <0.18 to <1 µm), glasswool-induced mesotheliomas and sarcomas were observed. In another study where female rats received coarse glasswool by intraperitoneal injection, abdominal tumors (mesotheliomas, sarcomas and, rarely, carcinomas) were induced. In another study, rats received glasswool, treated with an acid or an alkali, by intraperitoneal injection. The acid-treated glasswool induced mesotheliomas, sarcomas and, rarely, carcinomas. Alkali-treated glasswool also induced the formation of tumors in rats (IARC, V. 43, 1988).

The IARC Working Group on Man-Made Mineral Fibres and Radon (IARC Working Group) also reviewed five inhalation studies in rats. Although a few respiratory-tract tumors were observed in these studies, there was no statistically significant increase in tumor incidence. The IARC Working Group expressed concerns about the adequacy of most of these studies, noting factors such as short exposure period, small number of animals, lack of survival data, and failure to report fiber dimensions. The National Toxicology Program (NTP) scientific committees reviewed, in addition to the IARC Working Group's monograph, a more recent rat inhalation study (Hesterberg et al., 1993). The authors of this study also reported no statistically significant increase in lung tumor incidence. NTP reviewers of this study noted the high tumor incidence in the control group and expressed concerns that the doses administered may have been too low to elicit a response.

Debate continues in the scientific community regarding the use of implantation studies as indicators of carcinogenic potential of fibers. Some investigators maintain that only inhalation exposure is relevant to the manner in which humans are usually exposed (McClellan et al., 1992). The IARC Working Group noted that

> "Inhalation is the major route of exposure to mineral fibers that have been shown to cause cancer in humans (e.g., asbestos). Therefore, it is desirable to use the inhalation route, if possible, when testing such fibers for their carcinogenicity in animals; however, the qualitative and quantitative aspects of particle deposition and retention in rodents are considerably different from those in humans. As a result, particles that may be important in the induction of disease in humans may never reach the target tissues in sufficient quantities in rodents. This problem cannot be overcome by generating higher concentrations of particulate aerosols because of technical complications, e.g., particle aggregation. The consequence is that inhalation tests may be less sensitive than tests by other routes for evaluating the carcinogenicity of particulate and fibrous materials. In

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* There is no separate CAS Registry number assigned to glasswool.

addition, the high cost of and the shortage of adequate facilities for such studies severely limit the number that can be performed.

"It is thus often necessary that other routes of administration be used for testing the carcinogenic potential of mineral fibers. The methods that have been most frequently employed are intratracheal instillation and intrapleural and intraperitoneal administration. With the first, various lung tissues as well as the pleural mesothelium are the major targets for the administered test fibers; in the latter two, the pleural and the peritoneal mesothelium, respectively, are the target tissues. These routes of administration can be used to test the carcinogenicity of mineral fibers to laboratory animals because they bring the test fibers into intimate contact with the same target tissues as in humans" (IARC, V.43, 1988, Page 34).

There is inadequate evidence for the carcinogenicity of glasswool in humans (IARC, V. 43, 1988). A number of studies have been conducted of workers involved in the production of glasswool. Most of the studies identified the association of workers exposed to glasswool and lung cancer. In a Canadian study, there was a statistically significant excess of lung cancer among glasswool workers; however, there was no relationship between the length of employment and lung cancer mortality (IARC, V.43, 1988). In a U.S. study, Enterline et al. (1987) reported a small statistically significant excess in all malignant neoplasms and in respiratory cancer 20 years or more after first employment using local death rates to estimate expected deaths. In an update of this study, Marsh et al. (1990) reported that "overall the evidence of a relationship between exposure to man-made mineral fibers and respiratory cancer appears to be somewhat weaker than in the previous update" (Enterline et al., 1987).

PROPERTIES

Fibrous glass is the name for a manufactured fiber in which the fiber-forming substance is glass. Glasses are a class of materials made from silicon dioxide with oxides of various metals and other elements, that solidify from the molten state without crystallization. A fiber is considered to be a particle with a length-to-diameter aspect ratio of 3 to 1 or greater. Respirable fibers have mass median aerodynamic diameter approximately 3.5 µm or less. Fibers less than 1 µm in diameter have the highest probability for deposition in the alveolar regions of the lung, where gas exchange occurs (WHO, 1988).

Glasswool is produced by drawing, centrifuging, or blowing molten glass and comprises cylindrical fibers of relatively short length (compared with filaments) (IARC, V. 43, 1988).

USE

The major uses of glasswool are in thermal, electrical, and acoustical insulation, weatherproofing, and filtration media. In 1980, approximately 80% of the glasswool produced for structural insulation was used in houses. Glasswool, in the form of loose-bagged wool, is pneumatically blown or hand poured into structural spaces, such as between joists and in attics. Plumbing and air-handling systems also require insulation. Glasswool and glass fibers are used to insulate against heat flow with prefabricated sleeves. Sheet-metal ducts and plenums of air-handling systems are often insulated with flexible blankets and semirigid boards usually made of glass fibers. Small-diameter glass fibers (0.05-3.8 µm) have been used in air and liquid filtration, and glass fiber air filters have been used in furnaces and air conditioning systems.

Glass fiber filters have been used in the manufacture of beverages, pharmaceuticals, paper, swimming pool filters, and many other applications (IARC, V. 43, 1988).

PRODUCTION

These products were first produced in the U.S. in 1897 (IARC, V. 43, 1988). The annual production for glasswool is 1.2 x 10^6 tons (Kirk-Othmer, V. 11, 1980). In 1985, there were 58 plants in the U.S. that produced glasswool, rockwool, slagwool, or ceramic fibers.

EXPOSURE

Glasswool is released as airborne respirable particles during their production and use. As the diameter of the glasswool decreases, both the concentration of respirable fibers and ratio of respirable to total fibers increases. Occupational exposure levels have generally been 1 respirable fiber/cm^3 or less (Bender and Hadley, 1994). The highest levels of occupational exposure to glasswool have occurred when it is used in confined spaces. Outdoor air concentrations are much lower than those associated with occupational settings (IARC, V.43, 1988). NIOSH estimates that 200,000 workers are potentially exposed to fibrous glass (Sittig, 1985). Studies have indicated that exposure of users may exceed those of production workers (IARC, V. 43, 1988).

The primary routes of potential human exposure to glasswool are inhalation and dermal and/or eye contact. Large-diameter (greater than 3.5 µm) glass fibers have been found to cause skin, eye, and upper respiratory tract irritation. Smaller-diameter fibers have the ability to penetrate the alveoli. This potential is cause for concern and is the primary reason that the fibers are subject to special controls.

Animal studies have demonstrated carcinogenic effects with long (greater than 10 µm) and thin fibers (usually less than 1 µm in diameter). The studies were conducted by implanting fibrous glass in the pleural or peritoneal cavities. In an experiment where measurements were taken in four facilities producing fibrous glass insulation and one producing fibrous glass textile products, it was concluded that in terms of airborne concentrations of glass fibers and total dust, workers' exposure was negligible; the fiber concentrations in the asbestos textile industry were about 20-fold higher (IARC, V. 43, 1988). In addition, NIOSH recommends that workers subject to fibrous glass exposure have comprehensive preplacement medical examinations with emphasis on skin susceptibility and prior exposure in dusty trades. Subsequent annual examinations should give attention to the skin and respiratory system with attention to pulmonary function.

NIOSH recommends that occupational exposure to fibrous glass be controlled so that no worker is exposed to respirable fibers of aerodynamic diameter 3.5 µm or less ($\leq$ 3.5 µm diam.) and length of 10 µm or greater ($\geq$ 10 µm length) at an airborne concentration greater than 3 million fibers per cubic meter of air as a 10-hr time-weighted average (TWA) or to a total fibrous glass concentration greater than 5 mg/m^3 air as a 10-hr time-weighted average (TWA). The TWAs apply to any 10-hr work shift in a 40-hr work week (NIOSHb, 1977).

REGULATIONS

EPA regulates particulate emissions from glasswool insulation manufacturing plants under the Clean Air Act (CAA) new source performance standards. OSHA regulates glasswool under the Hazard Communication Standard and as a chemical hazard in laboratories. OSHA determined an 8-hr time weighted average (TWA) workplace permissible exposure limit (PEL) as 5.0 mg/m^3 (as total dust) or 3 fiber/cm^3 for fibers greater than 10 μm long. The American Conference of Governmental Industrial Hygienists (ACGIH) has set occupational exposure limits (OELs) at 1 fiber/cm^3 as a TWA (ACGIH 1997). Regulations are summarized in Volume II, Table B-67.